

Field Investigations of Reference Concentration for Sediment Transport Models

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Award Number: N0001400C0449

LONG-TERM GOALS

The scientific focus of this project is to better understand and predict reference concentration above the seabed. Models of sediment transport depend on parameterization of the near-bed concentration of suspended sediment (or “reference concentration”) in terms of dynamical and sedimentological measures. We will evaluate the accuracy and suitability of existing expressions for reference concentration, and based on our field investigations, provide improved definition of this important parameter.

This work will be accomplished as part of an ONR-sponsored Mine Burial Research Program. It will be coordinated with other investigators who are working together to understand the oceanographic and seafloor processes that affect bottom mines. The principal goal of this research is to develop specification of the near-bed reference concentration that is tested and supported by high-quality field measurements under different sedimentological and dynamical conditions in shallow-water marine environments.

OBJECTIVES

- Evaluate existing formulations for reference concentration C_o and their applicability for sediment transport modeling.
- Obtain high-quality field measurements of important parameters that contribute to better understanding of C_o . These include detailed near-bed measurements of velocity profiles, suspended sediment concentrations and size distributions, and particle settling velocities.
- Determine relationships between bottom velocities and stresses in shallow-water marine environments and near-bottom suspended sediment concentrations.
- Develop an accurate expression for C_o .

APPROACH

Our approach is to carry out field studies to obtain data that can be used to investigate C_o . These data will include, but may not be limited to, near-bottom velocity profiles, suspended sediment concentrations and sizes close to the seabed, bottom sediment sizes, and bed roughness. We will work

in conjunction with Dr. Yogi Agrawal, Sequoia Scientific Inc., in carrying out the field work and post-field analysis. The two main field sites will be in shallow water (water depths 10 – 20 m) off Tampa Bay, FL (early 2003) and off Martha's Vineyard, MA (early 2004).

Other collaborating investigators will obtain hydrodynamic and sediment dynamics data during the main experiments at nearby locations. In addition, instrumented mines will measure scour and burial during the experimental periods.

WORK COMPLETED

We conducted a pilot experiment at a coastal site off California (off the main pier at Santa Cruz, CA) in December, 2001. This experiment provided testing of new equipment and sampling techniques. Excellent data on currents and waves were gathered using a Pulse-Coherent Acoustic Doppler Profiler (PC-ADP, SonTek) and single point 3-axis Acoustic Doppler Velocimeter (ADV, SonTek), as well as sonar imagery of the seafloor using a sector-scanning sonar and a narrow-beam high-resolution bathymetric profiler (both instruments from Imagenex). The sonars are capable of resolving small-scale bedforms and small bathymetric changes at repeated intervals. During the field test the sonars were cabled to a recording station on the pier. We also are completing software and firmware developments for allowing the sonar data to be recorded in-situ. During the main experiments all data (hydrodynamic and imagery) will be recorded in-situ.

RESULTS

The pilot test of the PC-ADP, ADV-Hydra, and sonars was successful. A tripod containing the various instruments was lowered off the end of the main pier at Santa Cruz, CA, using a mobile crane truck. The sensors were hard-wired to a control center that was established in the cargo area of a container truck situated on the pier. We used the crane-truck to raise and lower the tripod from pier to seabed several times during the 6-day field test. The mean water depth at the end of the pier was about 8.2 m. We obtained 6 days of wave and current data with the PC-ADP, ADV, and pressure sensor. The basic sampling interval was 30 minutes. Wave data was obtained at 2 Hz for 10 minutes.

The sonars were used intermittently in order to manipulate settings and sampling schemes. All of the instruments worked successfully. Hourly-averaged current velocities measured at 80 cm above the bottom with the single-point ADV and at the corresponding level in the PC-ADP profile were identical within instrument error (differences always < 1 cm/s; mean difference < 0.2 cm/s).

Near-bottom wave orbital velocities were generally low (< 10 cm/s) except during a 16-hour period when a small storm passed through the local region. Prior to the small storm, bottom currents were weak and tidal (maxima of about 5 cm/s). Waves generally consisted of low amplitude swell with periods of about 10 - 12 s and heights of about 0.4 – 0.6 m. During the storm winds increased abruptly from the S-SW, and peak spectral wave period dropped dramatically to about 6 s. These local sea waves persisted for about 16 hours. Peak hourly wind speeds at the pier achieved 12 m/s during this storm. Surface wave heights determined from bottom pressure measurements reached 1.2 m. Maximum bottom wave speeds measured with the ADV (80 cm above the bottom) were 31 cm/s. During this period small sand ripples were observed in the scanning sonar records. The bottom in the study site was generally flat except for the small ripples. Surficial sediment was fine sand (mean diameter of about 0.1 mm). The PC-ADP performed successfully throughout the period.

IMPACT/APPLICATIONS

The results from the proposed investigations of C_o will make important contributions to ongoing modeling efforts in the Mine Burial Program, and to subsequent sediment transport modeling research. Most sediment transport models that have been developed for shallow ocean conditions require specification of the relationships between bottom stresses or shears to concentrations of suspended sediment near the bed. The existing formulations have not been tested and validated under combined wave-current flow conditions above a rough bed. This work will improve this aspect of our understanding and improve modeling of sediment transport.

TRANSITIONS

This work is part of the larger ONR Mine Burial Program efforts. It will be directly integrated into the overall understanding of how mines react to physical processes in shallow water, and into improved sediment transport models.

RELATED PROJECTS

This project is directly linked to one undertaken by Dr. Yogi Agrawal, Sequoia Scientific, Inc. We will work closely on field and analysis aspects of the research. Other key collaborators are Dr. Peter Howd, U. of South Florida (USF), and Dr. Peter Traykovski and Dr. Steve Elgar, Woods Hole Oceanographic Institution. We will coordinate the field planning and logistics in 2003 for the experiment off Tampa Bay with Dr. David Naar, USF.